Water Quality Evaluation of Aquifers Around Igboekwu and Environs, Southeastern Nigeria

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ABSTRACT

Water quality (physico-chemical and biological) of the aquifers of the Tertiary formation of Igboekwu and environs was evaluated using the World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality guidelines with water samples collected from twenty boreholes during pumping tests. The study area covers a total surface area of 450.56km² including towns like, Igboekwu, Ezinifite, Uga, Ekwulobia, Nanka, Oko, Aguluezechukwu, Umuchu, Achina, Ekwulumili and Ndiowu. Results showed that the area is underlain by two geological Units, Imo Shale and Nanka Sands, from which the aquifers were tapped. Analysis of the results of physical parameters showed that temperature is ambient, water is colourless, odourless and tasteless for all samples studied. Results of the water chemistry, however showed marked variations; pH values ranged from 5.20 at Ihuowelle Igboekwu to 6.80, at Ebele Achina (highest), total dissolved solids (TDS) from 11.20mg/l at Ezinifite to 71.40mg/l at Achina, turbidity nil, major cations and anions, calcium (Ca²⁺) ranged from 5.0mg/l at Okwuchiezeada Ezinifite to 42mg/l at Ndiowu, magnesium (Mg²⁺) ranged from 0.01mg/l at Uga to 0.18mg/l in Ekwulobia. Iron ion values ranged from 0.02mg/l to 0.35mg/l in Igboekwu, Umueze Uga (0.35mg/l), manganese, copper and residual chlorine were not detected; while Bicarbonate (HCO₃) ranged from 7.00mg/l at Ezinifite to 58.00mg/l at Uga and Sulphate (SO₄²⁻) ranged from 0.00mg/l at Igboekwu to 7.00 mg/l at Ekwulobia, sulphate ions were not detected in Ekwulobia, while in Umunze and Uga, Mn²⁺, Ca²⁺ and Cl⁻ ions were not detected either. Bacteriological results showed that total coliform and fecal coliform were zero. These results thus showed that the aquifers in the study areas contain portable water for domestic use if the wells are well constructed and harnessed.

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INTRODUCTION

The project area is located within Anambra State, Southeastern Nigeria and lies within latitudes 5°56'N and 6°40'N and longitude, 7°00'E and 7°10'E, encompassing Aguata, Aniocha and Orumba Local Government Area. These areas hydrologically fall within the Anambra Basin and more specifically within the Anambra River Basin (Fig. 1). The area has abundant surface water and groundwater resources.

The main river systems in the study areas are Odo, Obizi, Otalulu, Iyiagu and Uchu.

Geology and hydrogeology

The Anambra basin is one of the major inland sedimentary basins in Nigeria, which is bounded on the east by the Abakaliki anticlinorium and on the south-westerly direction by the Benin hinge-line, the limits of the Eocene growth faults of the Niger Delta. These growth faults extend from the Calabar hinge-line to the

Benin hinge-line through the Onitsha high. The basin is about 300km long in a northern southwest direction, extending between the Onitsha and environs in Anambra State and Lokoja area in Benue State. Its southwestern extreme is about 48km wide (Whiteman, 1982) (fig. 1). The stratigraphic succession in the Anambra Basin and environs have been discussed (Reyment, 1965; Whiteman, 1982; Hoque and Nwajide,

1984). A generalized geologic map of the basin adapted from the geological map of Nigeria by the Geological Survey of Nigeria (1974) is as shown in fig. 2. The geologic cross section shows that the study area is underlain by the Ameki Formation and the Imo Shale. The population here gets its water supplies from boreholes that tap from these two formations as well as from springs and streams.

Figure 1: Map of Nigeria Showing the Study Area (Egboka *et al*, 1993).

Figure 2: Geological Map of the Study Area (Abor, sheet 300).

The study area has an undulating topography, with a maximum elevation of 300m above sea level and a minimum elevation of 100m above sea level. The major surface water body found in the study area is the Orashi River. Other surface waters in the area include Otalulu, Uchu, Odor, Streams and the Obizi spring at Ekwulimi. Perennial and seasonal streams, springs drain the area.

There is connectivity existing between surface water systems and groundwater systems; the groundwater systems are recharged as a result of infiltration of parts of overland flow into the soil (Fetter, 2001; Heath, 1983). Figure 3 showed the drainage and location of the study area.

Figure 3: Drainage and Location Map of the Study Area (Adapted from Abor Map Sheet 300).

Climate and Vegetation

The study area lies within the humid tropical rain climate of Nigeria, with rainfall amounting to 2000mm per annum. In Aguata, the average annual temperature is 25.7°C and an annual average rainfall of 1975 mm (Fig. 4). The area experiences two climatic seasons; the rainy season (March to October) and the dry season (October to March). These seasons have variable regimes. The dry season has the coldest, direst windy period known as the harmattan between November and February. The rainy season has its peaks in July and September with a dip in August known as “the August break”. Much rainfall occurs as violent downpours, accompanied by lightning and thunderstorms, heavy flooding, soil leaching, sheet out wash and ground water infiltration and percolation. Minimum temperature is 23°C, maximum temperature is 34°C while the average temperature 28°C. Relative humidity is 80% during the raining season and 65% during the dry season (Okpoko, 1986). The driest month is December, with 11 mm of rain. The greatest amount

of precipitation occurs in September, with an average of 318 mm. March is the warmest month of the year. The temperature in average is 27.4°C. The lowest average temperatures in the year occur in August, when it is around 24.0°C. There is a difference of 307 mm of precipitation between the driest and wettest months. The variation in temperatures throughout the year is 3.4 °C.

The vegetation is characteristics of the humid tropical rainforest belt type of Nigeria, with trees, evergreen leaves and thick undergrowth. The vegetation cover has greatly reduced to Savannah type. It is characterized by open vegetative lowland interspersed with tall oil palm trees and deciduous trees. Agriculture practices are intensive, particularly along the hill slopes, dry river valleys and low-lying plains. These, further, reduce the vegetation to the aforesaid Savannah type. In some places, the vegetation has been cleared for agriculture, road construction, industrial sites and urban development.

Figure 4: Climate of the study area (Macmillian, 2007).

MATERIALS AND METHODS

In order to achieve the goals of this research, the materials and methods used were; topographic map of the area on scales of 1:100,000, 1:250,000 and 1:500,000, global positioning system (GPS), plastic containers, generating set, and water depth well sounder.

During standard pumping tests, twenty borehole water samples were collected for geochemical analysis. All the collected samples were carefully labeled according to the respective locations and put in an ice packed bag. The samples were properly labeled indicating the time of collection.

RESULTS AND DATA ANALYSES

Water quality was assessed using physical, chemical and biological parameters. The physical parameters investigated include appearance, temperature, colour, odour and turbidity. The chemical parameter investigated include pH, conductivity, total dissolved solids, salinity, copper, nitrite, manganese and the major cations and anions. The bacteriological parameters investigated were for fecal coliform count and total coliform. The results were presented in Tables 1 and 2. All investigations/assessment were carried out using standard recommended methodologies and interpreted against World Health Organization (WHO, 2001) and Nigeria Standard for Drinking Water Quality, recommendations/guidelines (NSDWQ, 2007).

Table 1: Statistical Analysis for Major Cations and Anions in Study Areas.

	Parameter	Mean	Standard Deviation	Variance	Range	Max.	Mim.
Physical	pH	5.80	0.26	0.07	0.80	6.30	5.50
	Conductivity (µs/cm)	67.13	29.10	844.00	104.90	141.50	36.60
	TDS(mg/l)	35.06	14.30	205.00	52.40	70.70	18.30
	Hardness (mg/l)	36.70	15.40	238.00	54.00	67.00	13.00
Cations	Calcium(Ca ²⁺) mg/l	24.20	9.30	87.30	33.00	41.00	8.00
	Magnesium (mg ²⁺) mg/l	15.80	6.30	39.30	21.00	29.00	8.00
	Sodium (Na ⁺) mg/l	22.0262	8.40	70.8215	28.842	367094	7.8674
	Potassium (K ⁺) mg/l	8.83	2.30	5.5099	8.29	13.05	4.76
	Bicarbonate (HCO ₃ ⁻) mg/l	35.65	20.00	392.00	72.00	80.00	8.00
Anions	Sulphate(SO ₄ ²⁻)mg/l	1.75	1.60	2.70	6.00	7.00	1.00
	Cl (Chloride)mg/l	4.9926	1.6484	2.7173	5.8212	7.9561	2.1349

Table 2: Results Microbiological Analyses.

	PHYSICAL PARAMETERS						CHEMICAL PARAMETERS																BACTERIOLOGICAL PARAMETERS			
	COORDINATES	APPEARANCE	TEMPERATURE °C	COLOUR (TCU)	TURBIDITY (NTU)	ODOUR	pH	CONDUCTIVITY µs/cm	TDS mg/l	SALINITY mg/l	CHLORIDE (cl) mg/l	CARBONATE (co_3^{2-}) mg/l	BICARBONATE (Hco ₃) mg/l	TOTAL HARDNESS (mg/l	CALCIUM (Ca ²⁺) mg/l	MAGNESIUM (mg ²⁺)mg/l	POTASSIUM (K ⁺) mg/l	SULPHATE (SO ₄ ²⁻) mg/l	NITRITE (SO ²)mg/l	NITRATE (NO ₂) mg/l	IRON (Fe ²⁺) mg/l	MANGANESE (Mn ²⁺) mg/l	COPPER (Cu ²⁺) mg/l	RESIDUAL chlorine (EL ₂)	TOTAL Coliform/100ml/H ₂ O	FEACAL Coliform 100ml/H ₂ O
1. Ihuowelle-Igboukwu	N06.01004- E007.00594	Clear	Ambient	Nil	Nil	Nil	5.7	28.6	14.3	Nil	Nil	Nil	9.0	40	18	10	8.0	Nil	10.5	0.03	4.0	0.21	0.03	-	0	0
2. Umume Umudege-Igboukwu	N06,00234, E007.2921	Clear	Ambient	Nil	Nil	Nil	5.8	31.4	15.7	Nil	Nil	Nil	10	31	9.0	22	-	Nil	Nil	Nil	0.27	Nil	Nil	-	0	0
3. Okwuchi Ezeada-Ezinifite	N05 ⁰ 59433 ¹ , E007.03.944 ¹	Clear	Ambient	Nil	Nil	Nil	5.8	22.3	11.3	Nil	Nil	Nil	7.0	15	5.0	10	-	7.0	0.01	1.76	0.03	Nil	Nil	-	0	0
4. Ezihe Umueze Uga	N05 ⁰ 55.304 ¹ E007 ⁰ 57.402 ¹	Cloudy	Ambient	90	17	Nil	5.9	38.4	19.2	Nil	Nil	Nil	58	19	7.0	12	-	2.0	Nil	Nil	0.35	0.01	Nil	-	1	1

Table 2: (Continued).

	PHYSICAL PARAMETERS						CHEMICAL PARAMETERS																BACTERIOLOGICAL PARAMETERS			
	COORDINATES	APPEARANCE	TEMPERATURE °C	COLOUR (TCU)	TURBIDITY (NTU)	ODOUR	pH	CONDUCTIVITY µs/cm	TDS mg/l	SALINITY mg/l	CHLORIDE (cl) mg/l	CARBONATE (CO_3^{2-}) mg/l	BICARBONATE (HCO_3^-) mg/l	TOTAL HARDNESS mg/l	CALCIUM (Ca^{2+})mg/l	MAGNESIUM (Mg^{2+})mg/l	POTASSIUM (K^+)mg/l	SULPHATE (SO_4^{2-}) mg/l	NITRITE (SO_2)mg/l	NITRATE (NO_2)mg/l	IRON (Fe^{2+})mg/l	MANGANESE (Mn^{2+})mg/l	COPPER (Cu^{2+})mg/l	RESIDUAL chlorine (EL ₂)	TOTAL Coliform/100ml/H ₂ O	FEACAL Coliform 100ml/H ₂ O
5. AgbakoAwarasi	N05.95515 ° E007.08338°	Clear	Ambie	Ni 1	Ni 1	Ni 1	5.80	33.50	16.70	Nil	Nil	Ni 1	7.00	12.00	7.00	5.00	-	3.00	Nil	4.40	0.20	Nil	Ni 1	-	6.00	0.00
6. Progressive Primary School Achina	N05.95299 ° E007.12221°	Clear	Ambient	Ni 1	Ni 1	Ni 1	6.45	142.50	71.40	16.50	10.00	Ni 1	79.00	86.00	52.00	34.00	-	2.00	0.02	4.40	0.20	0.01	Ni 1	-	3.00	0.00
7. Umuezeiyi Community, Achina	N05.96211 ° E007.12200°	Clear	Ambient	Ni 1	Ni 1	Ni 1	6.35	58.70	29.30	Nil	Nil	Ni 1	35.00	32.00	19.00	13.00	-	1.00	0.01	12.00	0.02	Nil	Ni 1	-	1.00	0.00
8. Okpo Ekwulobia	N06.01008 ° E007.09110°	Clear	Ambient	Ni 1	Ni 1	Ni 1	5.90	50.30	25.20	Nil	Nil	Ni 1	57.00	17.00	11.00	6.00	-	6.00	Nil	3.50	Nil	0.01	-	-	2.00	0.00
9. Umuchiana-Ekwulobia	N05.92925 ° E007.12572°	Clear	Ambient	Ni 1	Ni 1	Ni 1	5.80	78.00	39.00	Nil	Nil	Ni 1	8.00	13.00	7.00	6.00	-	8.00	0.01	4.40	0.02	0.03	Ni 1	-	8.00	3.00

Table 2: (Continued).

	PHYSICAL PARAMETERS						CHEMICAL PARAMETERS																BACTERIOLOGIC AL PARAMETERS			
	COORDINATES	APPEARANCE	TEMPERATURE °C	COLOUR (TCU)	TURBIDITY (NTU)	ODOUR	pH	CONDUCTIVITY μs/cm	TDS mg/l	SALINITY mg/l	CHLORIDE (cl) mg/l	CARBONATE (co ⁻²) mg/l	BICARBONATE (Hco ₃) mg/l	TOTAL HARDNESS mg/l	CALCIUM (Ca ²⁺)mg/l	MAGNESIUM (mg ²⁺)mg/l	POTASSIUM (K ⁺)mg/l	SULPHATE (SO ₄ ²) mg/l	NITRITE (S0 ²)mg/l	NITRATE (NO ₂)mg/l	IRON (Fe ²⁺)mg/l	MANGANESE (Mn ⁺⁺)mg/l	COPPER (Cu ²⁺)mg/l	RESIDUAL chlorine (EL ₂)	TOTAL Coliform/100ml/H ₂ O	FEACAL Coliform 100ml/H ₂ O
10. Ihokapala- Ekwulobia	N06.02993 ⁰ , E007.07469 ⁰	Clear	Ambient	Ni 1	Ni 1	Ni 1	5.8	35.60	17.8 0	Nil	Nil	Ni 1	3.00	9.00	6.00	3.00	-	4.0 0	Nil	7.0 0	8.0	0.1 8	0.0 1	-	0.00	0.00
11. Ebele- Achina	N05 ⁰ 57 ¹ 00.0 ¹ , E007 ⁰ 070.0 ¹	Clear	Ambient	Ni 1	Ni 1	Ni 1	6.4 5	142.5 0	71.4 0	16.5 0	10.0 0	Ni 1	79.0 0	86.0 0	52.0 0	34.0 0	-	2.0 0	0.0 2	4.4 0	0.2	0.0 1	Nil	-	3.00	0.00
12. Umugama Communit y, Umuchu	N05.92436 ⁰ , E007.12789 ⁰	Clear	Ambient	Ni 1	Ni 1	Ni 1	6.1 0	46.80	23.4 0	Nil	Nil	Ni 1	13.0 0	34.0 0	20.0 0	14.0 0	-	1.0 0	Nil	1.0 0	0.2	Nil	Nil	-	0.00	0.00
13. Agbaelu Communit y, Akpo	N05.97018 ⁰ , E007.10879	Clear	Ambient	Ni 1	Ni 1	Ni 1	5.2 0	98.60	49.1 0	5.00	3.00	Ni 1	12.0 0	62.0 0	37.0 0	25.0 0	-	Nil	0.0 1	8.0 0	Nil	Nil	Nil	-	0.00	0.00
14. Umumilo Communit y-Umuchu	N05.9434 ⁰ , E00713057	Clear	Ambient	Ni 1	Ni 1	Ni 1	6.1 0	72.50	36.0 0	Nil	Nil	Ni 1	92.0 0	58.0 0	34.0 0	24.0 0	-	2.0 0	Nil	2.6 0	0.2 0	0.0 1	0.0 1	-	0.00	0.00

Table 2: (Continued)

	PHYSICAL PARAMETERS						CHEMICAL PARAMETERS																BACTERIOLOGICAL PARAMETERS			
	COORDINATES	APPEARANCE	TEMPERATURE °C	COLOUR (TCU)	TURBIDITY (NTU)	ODOUR	pH	CONDUCTIVITY µs/cm	TDS mg/l	SALINITY mg/l	CHLORIDE (cl) mg/l	CARBONATE (CO ₃ ²⁻) mg/l	BICARBONATE (HCO ₃) mg/l	TOTAL HARDNESS mg/l	CALCIUM (Ca ²⁺)mg/l	MAGNESIUM (Mg ²⁺)mg/l	POTASSIUM (K ⁺)mg/l	SULPHATE (SO ₄ ²⁻) mg/l	NITRITE (SO ₂)mg/l	NITRATE (NO ₃)mg/l	IRON (Fe ²⁺)mg/l	MANGANESE (Mn ²⁺)mg/l	COPPER (Cu ²⁺)mg/l	RESIDUAL chlorine (CL ₂)	TOTAL Coliform/100ml/H ₂ O	FEACAL Coliform 100ml/H ₂ O
15. Special Education Centre Umuchu	N05.9295 ⁰ , E007.12572 ⁰	Clear	Ambient	Nil	Nil	Nil	6.10	72.50	36.00	Nil	Nil	Nil	92.00	58.00	34.00	24.00	-	2.00	Nil	2.60	0.20	0.01	0.01	-	0.00	0.00
16. Obeagu-Ezinifite	N05.98227, E007.06930	Clear	Ambient	Nil	Nil	Nil	5.80	22.30	11.30	Nil	Nil	Nil	7.00	15.00	5.00	10.00	-	7.00	0.01	1.76	0.03	Nil	Nil	-	0.00	0.00
17. Ndiowu	N06.32.112 ¹ , E00780.002 ¹	Clear	Ambient	Nil	Nil	Nil	5.70	66.00	35.00	Nil	Nil	Nil	40.00	65.00	41.00	22.00	-	1.00	Nil	1.00	Nil	Nil	Nil	-	1.00	0.00
18. Ekwulumili	N05 ⁰ 58401 ¹ , E007 ⁰ 02.279 ¹	Clear	Ambient	Nil	Nil	Nil	5.50	43.00	21.00	Nil	Nil	Nil	20.00	40.00	25.00	15.00	-	Nil	0.02	5.00	0.01	Nil	Nil	-	1.00	0.00
19. Ndiopaeze	N06 ⁰ 00.238 ¹ , E007 ⁰ 94.032 ¹	Clear	Ambient	Nil	Nil	Nil	5.70	50.00	24.00	Nil	Nil	Nil	17.00	31.00	25.00	20.00	-	Nil	0.01	1.00	Nil	Nil	Nil	-	0.00	0.00
20.Oko	N06 ⁰ 25.3201 ¹ , E007 ⁰ 41.321 ¹	Clear	Ambient	Nil	Nil	Nil	6.00	70.00	33.00	Nil	Nil	Nil	30.00	26.00	30.00	17.00	-	Nil	0.01	1.00	Nil	0.02	Nil	-	0.00	0.00

Statistical methods were used to obtain the mean, range, variance and standard deviation for the pH and major anions and cations found in water samples of the study area. The mean pH is 5.8 with range of 0.8, variance of 0.07 and standard deviation of 0.26. The mean value for conductivity is 67.13uS/cm, range is 104.9uS/cm, variance is 844uS/cm and standard deviation is 29.1uS/cm. Calcium and Magnesium ions gave mean values of 2.4mg/l and 15.8mg/l, range of 33mg/l and 21mg/l, variance of 87.3mg/l and 39.3mg/l and standard deviation of 9.3mg/l and 6.3mg/l respectively. The mean value for sodium is 22.0262mg/l, range is 28.842mg/l, variance is 70.8215mg/l and standard deviation of 8.4mg/l. Potassium value is 8.83mg/l for mean, 8.29mg/l for range, 5.5099mg/l for variance and 2.3mg/l for standard deviation. The $\text{Ca}^{++}\text{Mg}^{++}$, Na^{+} and K^{+} cations analysed fall within the recommended standard for potable water World Health Organisation (WHO), 2006. The mean sulfate concentration is 1.75mg/l range is 6mg/l, variance is 2.7mg/l and standard deviation is 1.6mg/l. Chloride value for mean is 4.99mg/l range is 5.82mg/l, variance is 2.72mg/l and standard deviation is 1.65mg/l. The bicarbonate ion has a mean value of 35.65mg/l range is 72mg/l, variance is 392mg/l and standard deviation is 20mg/l. A mean value of 36.7mg/l for total hardness was obtained, range is 54mg/l, variance is 238mg/l and standard deviation is 15.4mg/l. Mean of 35.06mg/l was obtained for Total dissolve solids. (TDS), range of 52.4mg/l, variance of 205mg/l and standard deviation of 14.3mg/l. Which all fall within the recommended standard for potable water World Health Organization (WHO), 2006 Guidelines.

Chemical Analysis: In order to have a more defined and clearer picture of the chemistry of the water under study, the data acquired were further processed using the piper, Durov, Piper and Schoeller semi log diagrams

Piper diagram

The major ionic species in most natural waters are Na, K, Ca, Mg Cl, CO_3 , HCO_3 , and SO_4 . This trilinear diagram showed the percentage composition of three ions. Na and K, the major cations were grouped; there are also three groups of the major anions (Fig. 5). Since all three constituent groups are present, the analyses fell in the interior of the field. The diamond-shaped field between the two triangles was then used to represent the composition of water with respect to both cations and anions. The cation point was projected onto the diamond-shaped field parallel to the side of the triangle labeled magnesium and the anion point was similarly projected parallel to the side of the triangle labeled sulfate. The intersection of the two lines was plotted as a point on the diamond-shaped field. This exercise revealed that the type of water present is calcium, magnesium and bicarbonate types.

Schoeller semilogarithmic Diagram

Schoeller Diagram (Freeze and Cherry, 1979), which was used to verify the results obtained from the Piper diagram, allowed us to make a visual comparison of the compositions of different waters, (Fig. 6). Sodium and Potassium were grouped and the result showed that magnesium is the dominant type followed by calcium and then, bicarbonate.

Figure 5 Graphical Illustration of Hydrogeochemical Data on the Piper Diagram.

Figure 5: (Continued).

Figure 6: Schoeller Diagram.

Table 3: Nigeria Standard for Drinking Water quality (adopted from Standards Organization of Nigeria, 2007).

	PARAMETER	UNIT	MAX. PERMISSIBLE	HEALTH IMPACT
PHYSICAL PARAMETER	Colour	TCU	15	None
	Odour	-	Unobjectional	None
	Taste	-	Unobjectional	None
	Temperature	°C	Ambient	None
	Turbidity	NTU	5	None
	Conductivity	Us/cm	1000	None
	Copper (Cu ²⁺)	Mg/L	1.00	Gastrointestinal disorder
CHEMICAL PARAMETERS	Chloride (CL ⁻)	Mg/L	250	None
	Hardness	Mg/L	150	None
	Iron fe ⁺²	Mg/L	0.30	None
	Magnesium	Mg/L	0.20	Consumer acceptability
	Manganese	Mg/l	0.20	Neurological disorder
	Nitrate (NO ₃)	Mg/L	50.00	Cyanosi and Asphyxia(blue baby syndrome)in infants under 3 months
	Nitrite(NO ₂)	Mg/L	0.20	Cyanosi and Asphyxia(blue baby syndrome)in infants under 3 months
	pH	-	6.5-8.5	None
	Sodium (Na)	Mg/L	200.00	None
	Sulphate(SO ₄)	Mg/L	100.00	None
	TDS	Mg/L	500.00	None
MICROBIOLOGICAL	Total Coliform	Cfu/mlo	10.00	Indication of faecal contamination
	Faecal coliform	Cfu/100ml	0.00	Indication of recent faecal contamination

DISCUSSION

Water quality analyses were carried out on some water samples collected from the study areas. In scope of this study can be divided into three domains. Microbial contamination refers to the presence of disease causing (or pathogene) microbes. Which are generally introduced to water sources by contact with faecal material. Chemical contamination refers to metals, organic compounds and other chemicals that present potential health risk. Physical contamination refers to condition relating to water physical condition, for example colour, odour, temperature and turbidity (cloudiness resulting from the presence of small particles like pieces of soil).

Water Quality analyses for physical parameter showed that the temperature was ambient, the water were colourless, odourless, and tasteless which was within the World Health Organization (WHO, 2006) permissible limit. The major chemical species in most natural waters are Sodium, potassium, magnesium, calcium, chloride, carbonates, bicarbonates and sulphates. For chemical parameters the pH ranged from 5.20 at Ihuowelle Igboekwu to 6.80, at Ebele Achina(highest),total dissolved solids (TDS) from 11.20mg/l at Ezinifite to 71.40mg/l at Achina ,turbidity nil, major cations and anions, calcium (Ca²⁺) ranged from 5.00mg/l at Okwuchiezeada Ezinifite to 42.00 mg/l at Ndiowu,magnesium (Mg²⁺) ranged from 0.01mg/l at Uga to 0.18mg/l in Ekwulobia,sulphate was not detected, iron ranged from 0.02mg/l to 0.35mg/l in Igboekwu, Umueze Uga (0.35mg/l), manganese, copper and residual chlorine were not detected whileBicarbonate (HCO₃) ranged from 7.00mg/l at Ezinifite to 58.00 mg/l at Uga and Sulphate (SO₄²⁻) ranged from 0.00mg/l at Igboekwu to 7.00mg/l at Ekwulobia .

Bacteriological result showed that total coliform and faecal coliform is zero. The water quality parameters tested fall within the World Health Organization (WHO, 2006) guidelines, desirable, permissible, acceptable limits and Nigeria Standard for Drinking Water Quality (NSDWQ, 2011) apart from the pH values which fall below the World Health Organization standard in some areas, though pH do not pose any health risk in water. The water quality of the groundwater resources in the study area is, therefore described as good. According to the Standard Organization of Nigeria, all water sources intended for human consumption shall comply with Nigeria Standard for Drinking Water Quality (NSDWQ, 2011) as shown in Table 3.

The graphical illustration of the hydrogeochemical analysis carried out using the Piper diagram, Stiff diagram, Shoeller semi logarithm diagram and Durov diagram all showed that “Calcium and Bicarbonate” were the main type of water in the study area and “Magnesium and Bicarbonate” were the additional type water.

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